Sustainability Action Plan for the Structural Engineer

By Robert C. Field, P.E., and Dirk M. Kestner, P.E.

Amidst building industry momentum for sustainability, especially the Leadership in Energy and Environmental Design (LEED®) Rating System, many structural engineers are still wondering how to make sustainability real within their everyday practice. To be sure, the vast majority of structural engineers should do more to understand sustainability and its relevance to structural engineering. By looking beyond the possible 69 credits of LEED to truly understand sustainability, we will be able to both contribute to the sustainability goals of our projects and apply principles of sustainability to our practice. This article suggests an action plan for the structural engineer asking how to make sustainability real in everyday practice. Three sequential steps are recommended: individual **education**, **incorporation** into firm operations, and **consolidation** across our profession.

> *"Sustainable Development...meets the needs of the present without compromising the ability of future generations to meet their own needs."*
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> *World Commission on Environment and Development's 1987 Statement, quoted by ASCE's Committee on Sustainability.*

Sustainability Concepts

What is **sustainability**? ASCE recently published an *Introduction to Sustainable Engineering Practice*, defining sustainability from many perspectives. Common to all of these perspectives is the idea that "sustainable approaches" provide for our current needs without compromising the ability of others to do so. Arguably, the best way to achieve this is by the judicious use of resources. This demands that we understand the environmental impacts of the materials we use, explore lower-impact alternatives, and seek opportunities to apply this knowledge.

Sustainability is the ultimate performance specification, one whose outcome cannot be fully measured for years. In the interim, the U.S. Green Building Council (USGBC) developed LEED as a prescriptive specification of sorts to push the marketplace towards sustainability. Its consensus-built standards are achievable using today's technologies, and include credits for such things as achieving given percentages of recycled content or using materials which meet given limits on air contaminants. Christopher Hewitt's January 2005 STRUCTURE article provided an excellent introduction to LEED. Although LEED has moved the industry towards more sustainably-designed buildings, its shortcomings, which include a lack of regional adaptability and inability to evaluate the life cycle impacts, must be understood.

Life Cycle Analysis (LCA) is a method of analyzing the environmental impact of a material or product through its full life. LCA evaluation systems currently include National Institute of Standards and Technology (NIST) developed BEES and AthenaSMI. A recent article in *Structural Engineering International*, by Mark Webster, P.E., provides an in-depth treatment of LCA for structural engineers. A related concept, **embodied energy**, is used as a simplified version of LCA, but can be misleading as an indicator of environmental impact. Merely summing the energy of a product over its lifespan omits other significant impacts, such as impact on habitat. As a result, this concept can fail to capture the impact of using a product such as old-growth timber. We must not limit ourselves to learning about LEED. By educating ourselves about sustainability and applying even a few of the principals in each project, we can start to accomplish something positive.

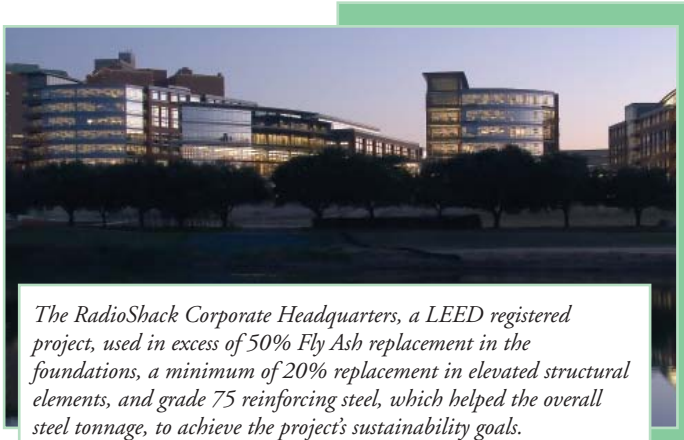
Step 1: Individual EDUCATION

Any structural engineer serious about environmentally responsible design must first educate himself about sustainability. Blindly pursuing traditional LEED points without understanding sustainability principles will inevitably lead to overlooked opportunities. The LEED system recognizes and rewards ideas outside its framework with "innovation credits," so the wise structural engineer should be unafraid to look beyond conventional green solutions.

Structural engineers should also look outside our own discipline. We must understand green architectural solutions such as light shelves, awnings, and green roofs. We must become partners with mechanical engineers as they seek ways to reduce heated roof space or optimize a roof structure for natural ventilation. We must be an informed member of an overall team effort.

Step 2: INCORPORATION into firm operations

Besides educating individuals in sustainability, engineering firms must build elements of sustainability into their design processes. At the 2005 Structures Congress, Helena Meryman (*see article this issue*) highlighted her firm's process for revising specifications to include green materials and methods which simultaneously familiarizes contractors with these options and helps create demand for them. Updating specifications should involve collaboration between spec writers, Green Team members, and those who've worked on sustainable



The RadioShack Corporate Headquarters, a LEED registered project, used in excess of 50% Fly Ash replacement in the foundations, a minimum of 20% replacement in elevated structural elements, and grade 75 reinforcing steel, which helped the overall steel tonnage, to achieve the project's sustainability goals.
© Blake Martin/HKS

buildings. Specifications for concrete, steel, timber, adhesives, curing compounds and sealants should be cross-referenced to corresponding "green documents" such as LEED criteria and the Building Green publication *GreenSpec*. As Ms. Meryman emphasized, careful research is needed before changing specification wording; conveyance of intent is crucial.

Most structural engineers are familiar with the green value of fly ash as a replacement for Portland cement in concrete. Few, however, have taken the further step of standardizing even modest replacement ratios (say 5 to 10%) in elements such as foundations, walls, and columns, with appropriate accommodation of the slightly slower cure rate of the resulting mixes. Considering that the production of Portland cement results in 7% of the world's CO_2 emissions, this simple step would make a substantial environmental contribution. The delay in strength gain due to fly ash substitution could be easily accommodated by specifying concrete strengths at 56 days rather than the traditional 28 days.

The structural steel member's sizes and connection details in EcoWorks Building One, a LEED Certified Building, were selected with appearance in mind. These architect-approved elements allowed the structure to remain exposed and reduced the amount of finish material. ©Mike Sullivan Photographer

Though typically conservative by nature, structural engineers must remain open to the use of **new materials**. Application of new materials can be a frustrating process, since design and building codes often won't accept materials until they're proven. Some engineers have been more aggressive than others in this regard, with surprising results. Bruce King, a structural engineer in California, has long been a proponent of regional and indigenous building materials, and has compiled an impressive array of research on the shear and flexural properties of straw bale, a building material that most structural engineers would not consider. Straw bale construction gets publicity because it sounds "far out", but like any building material, it can be evaluated by its material properties. It is simply a composite system of bales, with a facing of stucco. Like concrete masonry, it can be load-bearing, or used as infill within a frame. (*see article this issue*) Armed with research like King's and working closely with building officials, a few architects have added straw bale construction to their design palette. HOK's 26,000 SF Santa Clarita, CA Transit Maintenance Facility showcases this non-traditional material.

Reduce, Reuse, & Recycle

Reduce

Next to using nothing, using *less* is the best way to minimize environmental impacts. Structural engineers are experts at designing for efficient use of materials. While executing scheme studies to evaluate potential structural systems, engineers should consider both material quantities and life cycle impacts.

Reducing also means using fewer harmful materials. Structural systems are painted, sealed, cured, galvanized, and adhered. Structural engineers must become far more familiar with the characteristics of these materials and seek to specify those that minimize environmental impact and building toxicity. We can even indirectly reduce material usage, perhaps by proposing an architecturally exposed structural system to reduce architectural finishes.

Reuse

When salvaged materials are reused, nothing new must be manufactured. Though materials with an unknown past demand caution, structural engineers could be more aggressive and knowledgeable in material testing techniques, adapting "new material" design approaches to reused materials, and encouraging contractors to obtain and use salvaged materials.

Recycle

Recycled content reduces both the land-filling of used materials and the impact of extracting new materials, and, as a result, is one of the most popular qualities of green materials. Recycled products offer consistent material properties dues to their controlled manufacturing process. However, this, like any other manufacturing process, causes environmental impacts. But, by encouraging post-consumer recycling over post-industrial recycling, we can still make gains in the push toward sustainability. Post-consumer recycled products have reached the end of their useful consumer life before being returned to the manufacturing stream, reducing virgin material input and processing energy. Post-industrial recycling, however, uses materials that never made it out of the manufacturing stream and therefore offers vastly reduced benefit to the environment.▪

Other indigenous materials, like adobe, can be evaluated in a similar manner, as can more modern materials such as Autoclaved Aerated Concrete (AAC). AAC can be considered a green building material since it is used like masonry, but with far better insulating properties. Its light weight reduces the impact of transportation, and in some locations it is being manufactured using fly ash. AAC is well established in Europe, and many construction resources are available.

As firms explore alternative materials, they must wisely manage the risks. A deliberate system of researching, reviewing, and incorporating new materials and approaches into their existing design framework is a must.

Step 3: CONSOLIDATION across the profession

To become true partners in the effort to create more sustainable buildings, structural engineers must consolidate the disparate efforts underway to bring some standardization and better capture lessons learned. This will free individual firms to move farther and faster by reducing the risks of innovation, while simultaneously encouraging all firms to adopt sustainable strategies. The Structural Engineering Institute (SEI) is in the process of forming a Sustainability Committee, which will bring needed direction and focus to consolidation efforts. (see SEI Structural Columns in this issue for information on the Committee) The ideas described below are just a fraction of the sustainability concepts that merit further consideration among architects, owners, developers, building trade organizations, and structural engineers.

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- **Design for Deconstruction:** Practical design standards and details for deconstruction would facilitate the disassembly of a building at the end of its useful life. Studies in this area by several organizations could be consolidated into a body of knowledge.
- **Design for Adaptability:** Practical design standards for adaptability are not yet developed. Standardized guidelines would help lead engineers to design more adaptable buildings.
- Use of **crushed concrete:** In highway construction, crushed concrete is frequently used as backfill and road base material, and some states have used it as coarse aggregate in paving concrete. However, it is rarely used in commercial structural construction. Engineers should obtain local sources and consider it as base or fill material for their projects.
- Use of **salvaged structural members:** Salvaged elements are not commonly used, due to the economic incentives of the demolition processes and because engineers are reluctant to reuse "materials with a past." Material-specific standards and testing procedures would be helpful to practicing engineers.
- Standardization of **fly ash and slag** as Supplementary Cementitious Materials: Though many studies and sources of information exist on the use of High Volume Fly Ash (HVFA) and slag in concrete, CMU, mortar & grout, there remains uncertainty in the profession regarding application of these materials at higher volumes. Standards would help.

Recycled crushed concrete aggregates were specified as granular base under slab-on-grades and non-drainage backfill for the Georgia Institute of Technology's Management Building at Technology Square, a LEED Silver Building. ©Brian Gassel/TVS

Conclusions

Structural engineers are good at sharing information within the industry, and sustainability is an area that desperately needs case studies, research results, and lessons learned. Compared to other areas of structural practice, the sustainability body of knowledge is thin, but growing quickly. Finally, structural engineers must overcome their reluctance to find a voice in industry organizations such as the USGBC. We should be leaders in these organizations, as well as in efforts to obtain code acceptance for new materials and methods.

By following this three-step action plan, structural engineers will grow at several levels and become more green, more relevant, and of more value to their clients and to society. By working together as a profession, we can play a larger role in developing a more sustainable future.▪

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Walter P. Moore's Green Team

Mission: Our Green Team is the definitive group of professionals who will enable Walter P. Moore to build a more environmentally responsible engineering practice by identifying and disseminating sustainable design options and strategies, and by finding practical ways to incorporate sustainability in our everyday practice.

Objectives:

1. Enhance design by building and maintaining an accessible body of knowledge about structural issues and opportunities related to the sustainable design of buildings, and establishing a process to gather, organize and disseminate information about sustainability.
2. Make the firm a better environmental steward through creation of best practices, recycling and purchasing programs, and overall environmental awareness in all our offices and by our staff.
3. Reach outside the firm through involvement in the professional sustainable design community, both at the local and national levels.

Professionals in every office who have a personal interest in sustainability and related emerging technologies are welcome to join the Green Team. Individuals are encouraged to follow their personal passion in these areas. A decentralized web-based approach is used, so contributions come easily from all corners of the Walter P. Moore organization. So far, the Green Team has developed firm-wide sustainability guidelines, modified technical specifications, become a presence at USGBC chapters in several locations, and developed white papers on numerous green technologies and design approaches.

At the University of Florida's Rinker Hall — a LEED Gold Building and AIA/COTE Green Project Award Recipient — moment connections were used to provide open bays which facilitate future expansion and adaptability. Image courtesy of Walter P. Moore.

Company leaders encourage Green Team participation and sponsor members to become LEED® Accredited, and active in USGBC and other green organizations. Yearly national conferences (e.g., GreenBuild, Greenprints) are attended by a handful of representatives who've shown extra commitment. Training opportunities, including USGBC LEED training, are also provided. Membership in organizations like USGBC help give us an inside ear into how LEED is developing, as well as showing a commitment to the sustainability industry. Subscriptions for *Environmental Building News* (EBN) provide a great tool for all our Green Team members.

Small steps that make a difference:

- After conferences or training, attendees post their notes on the firm's Intranet, GreenNet.
- Regular Green Team conference calls encourage individuals to highlight activities.
- Sustainable efforts are recognized in the firm newsletter and at stockholder gatherings.
- Client-oriented fact sheets are electronically published and distributed to the industry.
- Technical presentations to local AIA chapters and client firms are win-win.▪